MODELING PROTOCOL IN SUPPORT OF AN EIGHT-HOUR OZONE REDESIGNATION REQUEST AND MAINTENANCE PLAN FOR THE MARICOPA NONATTAINMENT AREA

Maricopa Association of Governments
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1. OVERVIEW OF MODELING STUDY

1.1 Background

Under the 1990 Clean Air Act Amendments, the Maricopa County nonattainment area was initially classified as Moderate for the one-hour ozone National Ambient Air Quality Standards (NAAQS). The area did not achieve the NAAQS for one-hour ozone by the required deadline of November 19, 1996. The one-hour ozone nonattainment area was subsequently reclassified to Serious, effective February 13, 1998. The deadline for Serious areas to attain the one-hour ozone standard was November 19, 1999. There have been no exceedances of the one-hour ozone standard in the nonattainment area since 1996.

The Maricopa Association of Governments (MAG) prepared the One-hour Ozone Redesignation Request and Maintenance Plan which was submitted to EPA in 2004 (MAG, 2004). EPA subsequently redesignated the Maricopa County one-hour ozone nonattainment area to attainment, effective June 14, 2005; EPA revoked the one-hour ozone standard on June 15, 2005.

On April 30, 2004, EPA published the final rule designating eight-hour ozone nonattainment areas, effective June 15, 2004. A 5,000 square mile area located mainly in Maricopa County and the portion of Pinal County that includes the City of Apache Junction, was designated as a nonattainment area for eight-hour ozone. The Maricopa eight-hour ozone nonattainment area is classified as “Basic” under Part D, Subpart I, of the Clean Air Act, with an attainment date of June 15, 2009.

MAG submitted the Eight-Hour Ozone Plan for the Maricopa Nonattainment Area (MNA) to EPA by June 15, 2007, as required by the Clean Air Act. The plan demonstrates attainment of the eight-hour ozone standard for all modeled episodes during the ozone season of 2008. Air quality monitoring data indicate that the MNA has not exceeded the eight-hour ozone standard since 2005. Thus, the area has attained the eight-hour ozone standard. However, EPA has not yet redesignated the area as an attainment area for the eight-hour ozone standard. An eight-hour ozone maintenance plan needs to be submitted to EPA as one of several requirements for the area to be redesignated as attainment.

As the designated regional air quality planning agency, MAG conducts modeling of emissions and pollutant concentrations and prepares maintenance plans necessary for redesignation to attainment. The ozone maintenance plan must provide for maintenance of the eight-hour ozone standard for at least 10 years after the area is officially redesignated to attainment by EPA. Lead time should be allowed for EPA’s review and approval action on the redesignation request. In determining the amount of lead time, EPA indicated that 18 months, as granted in section 107(d)(3)(d) of the Clean Air Act Amendments, should be assumed for EPA to approve a redesignation request (EPA Memorandum, 1992). Due to uncertainties regarding when the area will be redesignated to attainment, the year 2025 will be modeled to assure that the eight-hour ozone standard is maintained at least ten years after an official notice of redesignation to attainment by EPA.

1.2 Objectives

Key objectives to be accomplished in this protocol document are: (1) enhance technical credibility, (2) encourage the participation of all interested parties, (3) lay out responsibilities of all participants, (4) provide for consensus-building among all interested parties concerning modeling issues, and (5) provide documentation for technical decisions to be made in applying the models.

The protocol document describes the procedures MAG will use for conducting all phases of the modeling study. These include: (1) identifying the background, objectives, tentative schedule, and organizational structure, (2) developing the necessary input data bases, (3) performing quality assurance and diagnostic model analyses, (4) evaluating model performance and interpreting results, and (5) describing procedures for using the model to demonstrate whether adopted control strategies are sufficient to demonstrate maintenance of the eight-hour ozone standard.

1.3 Conceptual Description

EPA guidance (EPA, 2007) recommends that a conceptual description be formulated in developing a modeling protocol. A conceptual description is a qualitative way of characterizing the nature of an area's nonattainment problem. MAG developed an initial conceptual model for the eight-hour ozone attainment demonstration modeling by following EPA's guidance (MAG, 2007a). The conceptual model has been updated by supplementing recent air quality and emissions data for the present study. The eight-hour ozone exceedance problem in the MNA is characterized as: (1) The peak hourly ozone concentration occurs between 3 pm and 7 pm, and the minimum is usually reached at approximately 6 am. The diurnal cycle is stronger at sites located closer to central Phoenix. The diurnal variation is less prominent at sites farther away from central Phoenix. (2) More than 90 percent of high ozone events occur when the daily maximum temperatures are above 90° Fahrenheit (F). High ozone levels tend to occur when dew point temperatures are higher than the average. (3) 24-hour back trajectories on high ozone days indicate that the eight-hour ozone exceedances in the nontattainment area are likely caused primarily by local factors, rather than by regional transport. (4) In 2008 the nonattainment area exhibits a NOx-disbenefit in the urbanized portion of the eight-hour ozone modeling domain and a NOx benefit in the non-urbanized portions of the modeling domain. (5) Annual trends of eight-hour ozone design values and NOx at monitoring sites indicate that eight-hour ozone air quality in the MNA has been gradually improving. A detailed conceptual description is provided in Attachment I.

1.4 Management Structure and Committees

MAG has responsibilities for regional involvement in a number of planning issues, and has established an extensive mechanism for ensuring coordinated policy direction from elected officials, coordinated management and technical input, advice from the appropriate agency staff, as well as direct citizen input. Figure 1-1 displays the MAG Policy Structure and Figure 1-2 presents the MAG Committee Structure. All policy committees and formal technical committees follow the Arizona open meeting law which requires, among other requirements, the posting of meeting notices and agendas at least 24 hours prior to any meeting.

The MAG Regional Council is the governing body of MAG. It is comprised of elected officials from each member agency, two ex-officio members representing the Arizona State Transportation Board, and a representative from the Citizens Transportation Oversight Committee. This composition of elected officials is a reflection of citizen input at the local government level. The MAG Regional Council agenda includes a call to the audience, providing the opportunity for public comments at each monthly meeting. MAG holds at least one formal public meeting prior to the adoption of any new or update to the nonattainment area plan. Formal public meetings are advertised locally at least 30 days prior to the meeting date and documentation is available for public review during this 30-day period. Draft documents are distributed to appropriate federal, state, and local agencies for review and comment during this period. Comments received are analyzed with a staff response for consideration by the MAG Air Quality Technical Advisory Committee and MAG Regional Council before taking approval action. Documentation of the comments and responses are incorporated into the plan document.

Due to the technical complexity of many MAG programs, committees consisting of professional experts are often needed to assist in program development. The Air Quality Technical Advisory Committee is composed of representatives from eight MAG member agencies, citizens, environmental interests, health interests, automobile industry, fuel industry, utilities, public transit, trucking industry, rock products industry, construction firms, housing industry, architecture, agriculture, industry, business, parties to the Air Quality Memorandum of Agreement, and various State and Federal agencies. The role of the Technical Advisory Committee is to review and comment on technical information generated during the planning process and make recommendations to the MAG Management Committee.

1.5 Participating Organizations

Technical oversight for this project will be provided by the Air Quality Planning Team. This team includes staff representatives from the Maricopa Association of Governments (MAG), the Arizona Department of Environmental Quality (ADEQ), the Arizona Department of Transportation (ADOT), and the Maricopa County Air Quality Department (MCAQD). The activities of this working group are directed by a Memorandum of Agreement among the agencies involved (see Attachment II). Representatives of other agencies, including EPA and the U.S. Department of Transportation, will be consulted on technical matters, as needed. The Air Quality Planning Team will meet as necessary during the ozone modeling effort. Periodic reports on the status and progress of various phases of the modeling work will be presented at these meetings, and technical issues will be discussed and resolved.

1.6 Schedule

The eight-hour ozone air quality analysis for the Maricopa Nonattainment Area will include the following tasks. The schedule for these tasks is presented in Table 1-1.

1. Prepare a protocol document (this document) describing the purpose, background, and the procedures to be followed in the remainder of the analysis. This document also specifies the modeling domain and identifies three modeling episodes. (Completion Date: March 31, 2008)

2. Develop emissions preprocessing and CAMx inputs for the future year 2025. (Completion Date: April 30, 2008)

3. Prepare onroad mobile source emissions using MOBILE6.2 and M6Link for the 2025 episode periods. (Completion Date: April 30, 2008)

4. Develop emissions inventories for modeling three episodes in 2025. (Completion Date: May 30, 2008)

5. Evaluate committed control measures, and reflect emission reduction benefits of the committed control measures in emission inventories. (Completion Data: June 30, 2008)

6. Perform CAMx simulations for 2025. (Completion Date: August 29, 2008)

7. Write draft Technical Support Document (TSD) and maintenance plan. (Completion Date: October 24, 2008)

8. Provide draft TSD for Air Quality Planning Team Review. (Completion Date: October 27, 2008)

9. Release the plan and TSD for public review. (Completion Date: November 21, 2008)

10. Provide the plan and TSD for public hearing. (Completion Date: December 15, 2008)

11. Obtain Air Quality Technical Advisory Committee recommendation. (Completion Date: January 29, 2009)

12. Obtain Management Committee recommendation. (Completion Date: February 11, 2009)

13. Get Regional Council approval for the plan. (Completion Date: February 25, 2009)

14. Submit the plan and TSD to ADEQ/EPA. (Completion Date: February 27, 2009)

15. Obtain EPA adequacy determination for conformity budgets (Completion Date: May 31, 2009)

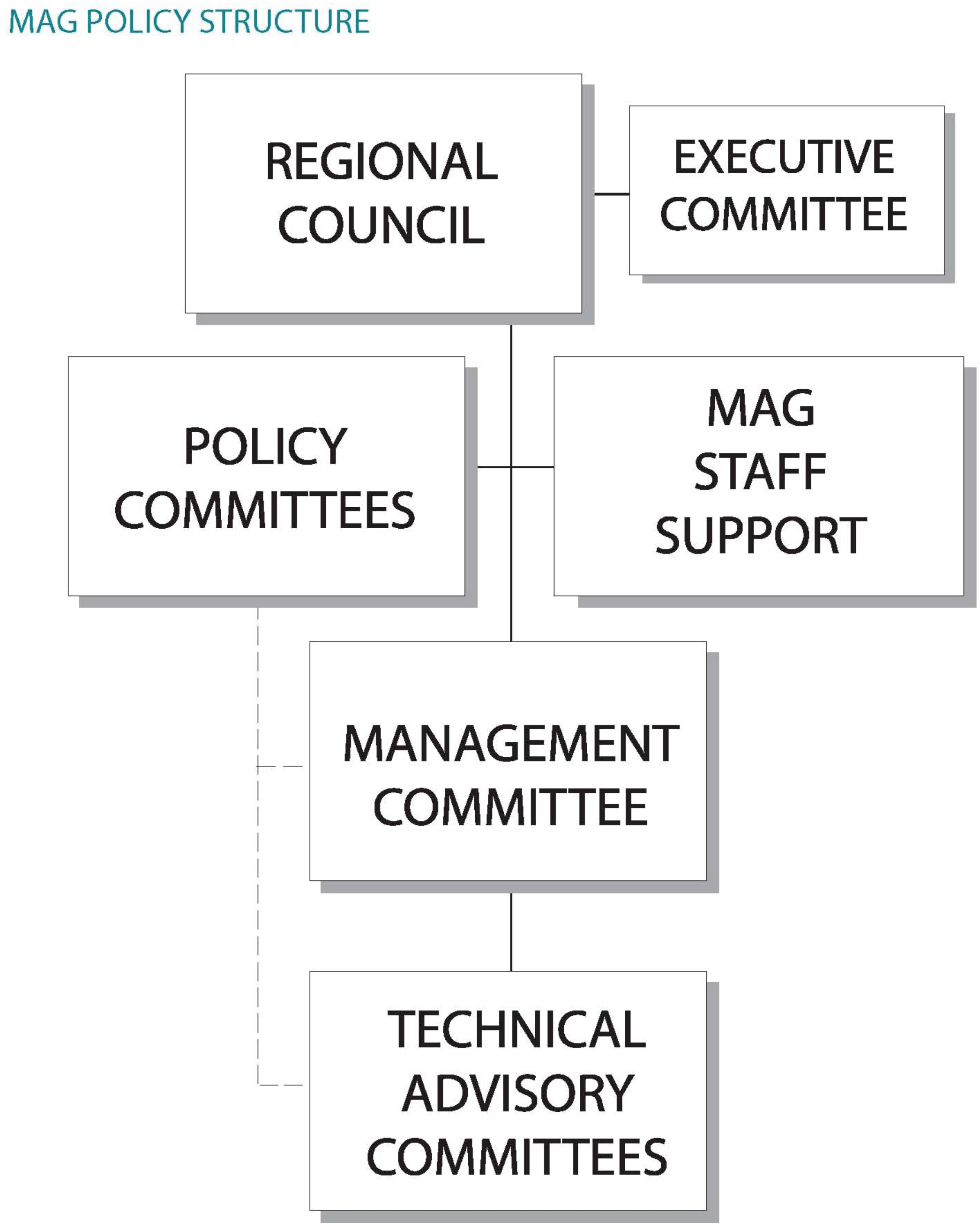

Figure 1-1 MAG Policy Structure

MAG COMMITTEE STRUCTURE

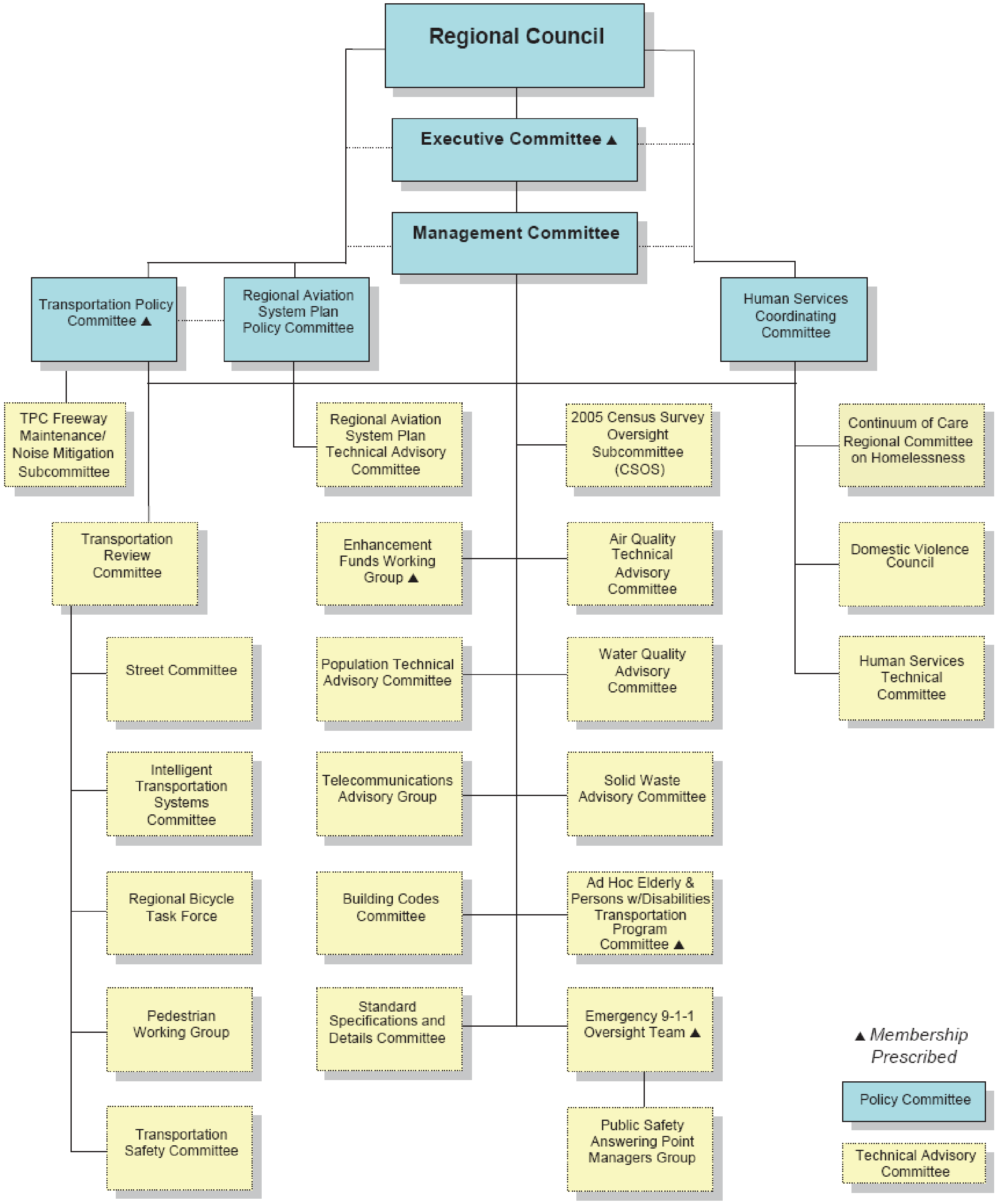

Figure 1-2 MAG Committee Structure

Table 1-1 Schedule for the Eight-Hour Ozone Modeling Demonstration for the MAG Eight-Hour Ozone Redesignation Request and Maintenance Plan for the Maricopa Nonattainment Area

8-Hour Ozone Maintenance Modeling Task List	2008										2009				
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Prepare modeling protocol document	★														
Prepare meteorological, emissions pre-processing and CAMx modeling inputs		★													
Conduct MOBILE6 modeling for onroad mobile source emissions		★													
Develop emissions inventories for modeling three episodes in 2025			★												
Committed control measure evaluation				★											
Complete CAMx simulations						★									
Write draft TSD and maintenance plan								★							
Provide draft TSD for Air Quality Planning Team review								★							
Draft plan document available for public review									★						
Public hearing										★					
Air Quality Technical Advisory Committee recommendation											★				
Management Committee recommendation												★			
Regional Council action												★			
Submit to ADEQ/EPA												★			
EPA adequacy finding for conformity budgets															★

Note: Assumes no additional measures beyond those in the Eight-Hour Ozone Plan and the measures in SB 1552 passed by the Arizona Legislature in 2007.

2. MODEL AND MODELING INPUTS

2.1 Rationale for Model Selection

To perform modeling for the eight-hour ozone maintenance demonstration, MAG considered three photochemical air quality models: 1) Comprehensive Air-quality Model with Extensions (CAMx), 2) Community Multi-scale Air Quality (CMAQ) model, and 3) Variable-grid Urban Airshed Model (UAM-V). EPA has indicated that any of these three models would be appropriate to simulate eight-hour ozone concentrations in urban areas (EPA, 2007). These models were evaluated according to the following selection criteria (see Table 2-1):

- Documentation and Track Record, and Advanced Technical Features - Since all three models have been peer-reviewed and adequately documented (EPA, 2007) and these models are state-of-the art photochemical air quality models equipped with advanced technological features, all of the models got the highest score for the first selection criteria - "Documentation and Track Record" and the second selection criteria, "Advanced Technical Features" (see Table 2-1).

- Recent Applications - In recent years, CAMx and CMAQ have been used more frequently in regulatory applications. EPA used CAMx to model eight-hour ozone in the eastern United states for the Clean Air Interstate Rule (CAIR). CMAQ has been used by the Western Regional Air Partnership to model visibility in the western United States. EPA has also used CMAQ to model PM-2.5 and visibility for the CAIR. UAM-V has been applied less frequently than CAMx or CMAQ. For these reasons, CAMx and CMAQ got the highest scores for the third selection criterion of "Recent Applications".

- Experience of MAG Staff - MAG staff members have extensive experience with CAMx and its pre- and post-processors during MAG's modeling for the eight-hour ozone attainment demonstration. Thus, CAMx got the highest score for the "Experience of MAG staff" criterion. In addition, MAG staff compared CMAQ's modeling performance with CAMx's modeling performance for the three episodes adopted in the MAG Eight-Hour Ozone Plan. The CAMx model had a slightly better modeling performance than the CMAQ model for the three episodes. A more detailed description of the CMAQ's modeling performance evaluation is available in Attachment III of this protocol.

- Flexibility - All three models have good computational efficiency, but UAM-V is a proprietary model, unlike CAMx and CMAQ. Therefore, UAM-IV scored the lowest number for the flexibility criterion.

Overall, since CAMx got the highest scores for the selection criteria, MAG recommends that CAMx is the most appropriate photochemical air quality model for use in the present study.

Figure 2-1 depicts the MAG air quality modeling chain with CAMx as the core model. Most of CAMx input files will be prepared using preprocessor programs. The Emissions Preprocessor System, EPS3.0, will be used to process emission inventories (ENVIRON, 2005). The onroad mobile emissions will be generated by the EPA MOBILE6.2 model and M6Link. M6Link is a MAG-developed program to develop hourly gridded emissions for the photochemical air quality model. More detailed discussions on the preparation of the emissions inventory and meteorological inputs are provided later in this protocol.

Table 2-1 Attributes of Candidate Air Quality Models

Selection Criteria	CAMx	CMAQ	UAM-V
Documentation and Track Record	3	3	3
Advanced Technical Features	3	3	3
Recent Applications	3	3	2
Experience of MAG Staff	3	1	0
Computational Efficiency	3	3	3
Flexibility (Proprietary vs. Open Source)	3	3	0
Total	18	16	11
Scoring: 3 = highest and 0 = lowest			

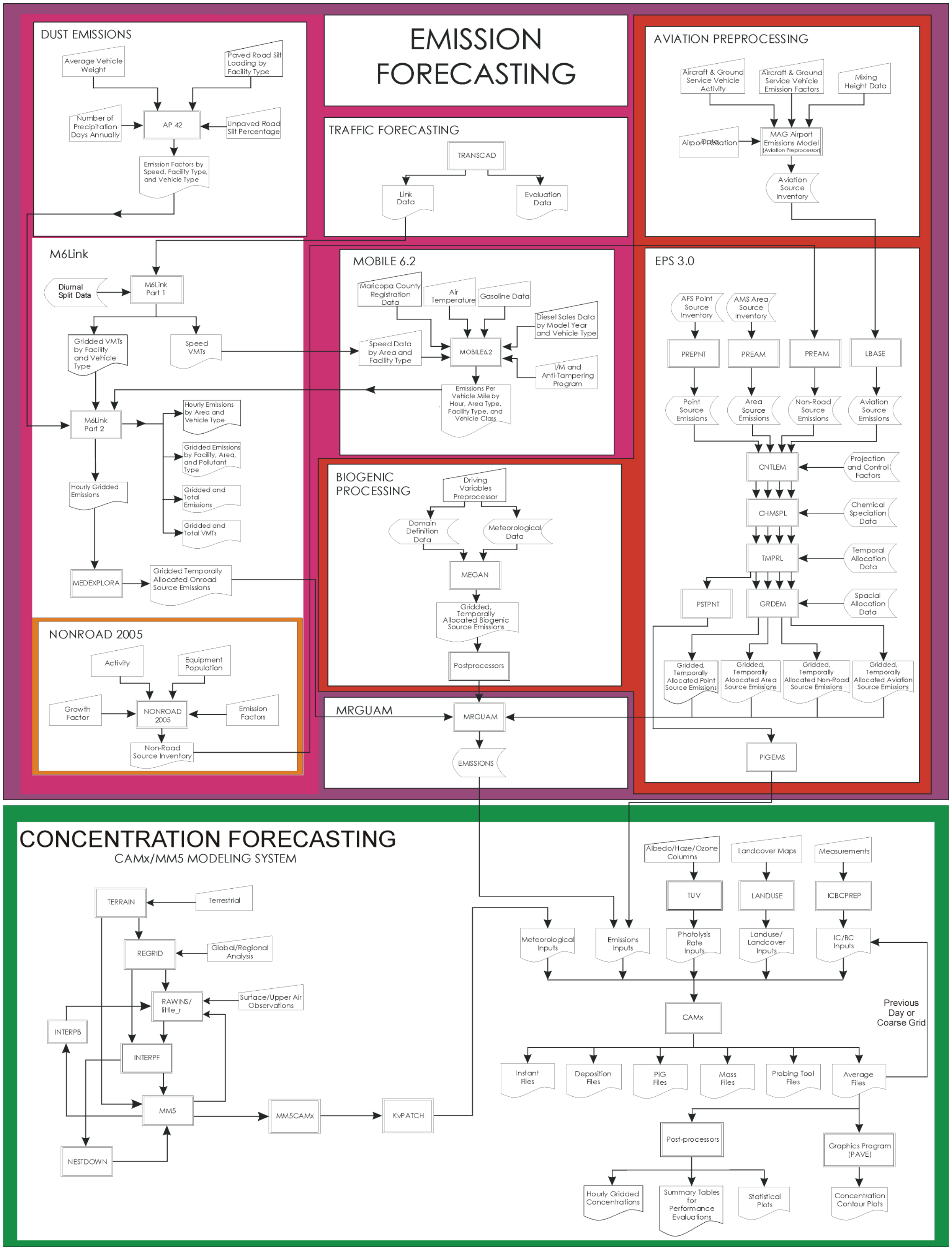

Figure 2-1 MAG Air Quality Modeling Chain

2.2 Modeling Domain and Horizontal Resolution

Selection of the 8-hour ozone modeling domains took into account the eight-hour ozone nonattainment area boundaries, the distribution of major emissions sources, the location of meteorological and air quality monitoring sites, and the prevailing winds associated with ozone episodes. Figure 2-2 illustrates the inner modeling domain comprised of 4 kilometer by 4 kilometer (km) grids along with the eight-hour ozone nonattainment area boundaries. Figure 2-3 shows the spatial relationship between the inner (4 km grid) and outer (12 km grid) CAMx and MM5 modeling domains.

MAG's previous study of 36-hour back-trajectory air flow patterns demonstrated that the outer 12 km grid CAMx domain (shown in Figure 2-3) is of sufficient size to capture the transport characteristics for the ozone episodes to be modeled (MAG, 2007). As for the meteorological modeling, MM5 will utilize three nested domains, at 4 km, 12 km, and 36 km grid resolutions, to simulate the selected episode periods. As shown in Figure 2-3, the boundaries of the 4 km and 12 km MM5 modeling domains are larger than the CAMx modeling domains.

The inner CAMx modeling domain encompasses the entire eight-hour ozone nonattainment area and consists of 50 grid cells (4 km) in the west-east direction and 29 grid cells (4 km) in the south-north direction. The origin, at the southwest corner of the inner domain, is located at 297 km Easting and 3,652 km Northing in UTM Zone 12. The inner CAMx modeling domain has an area of approximately 9,000 square miles.

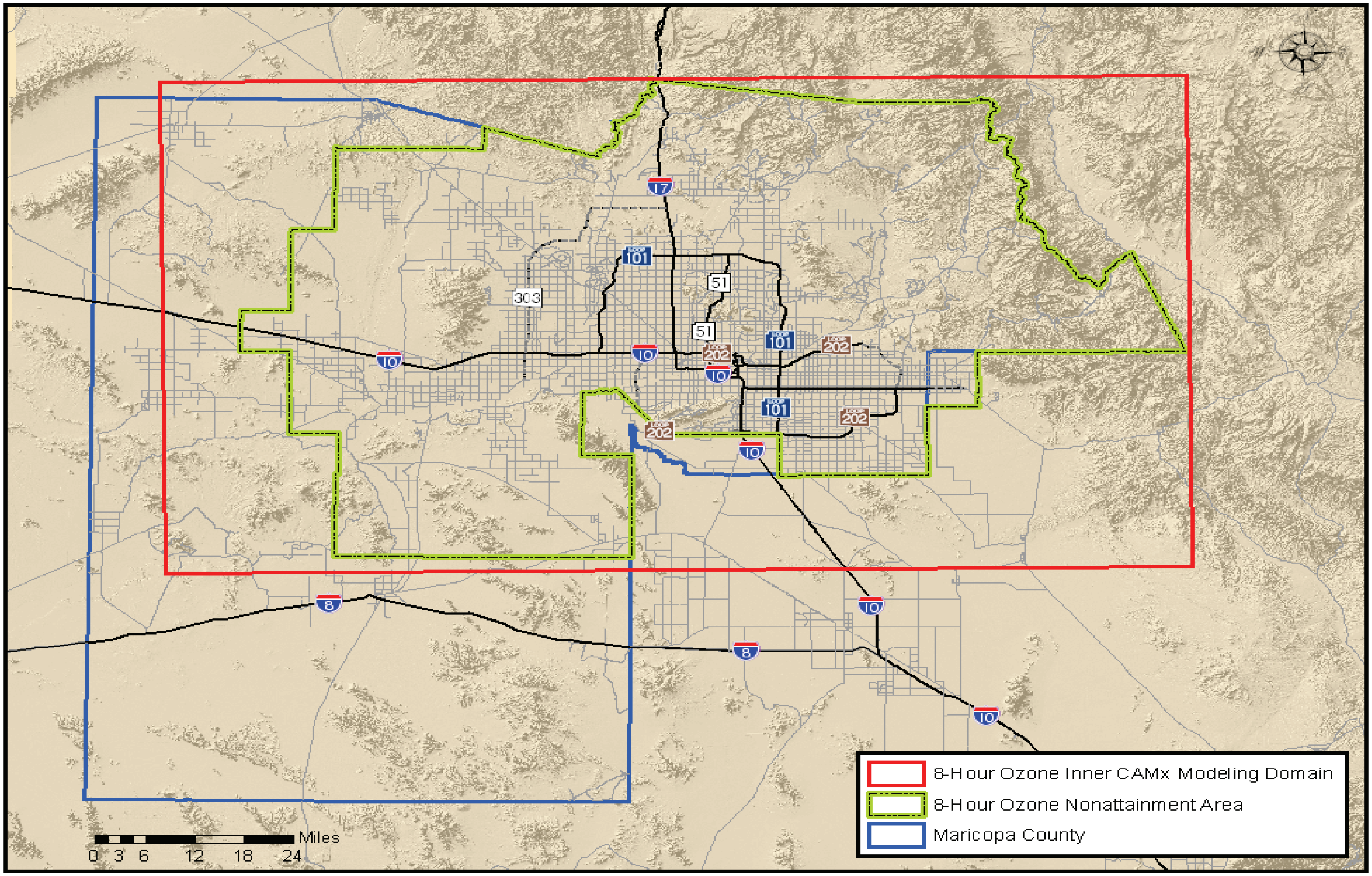

Figure 2-2 The Inner CAMx Modeling Domain

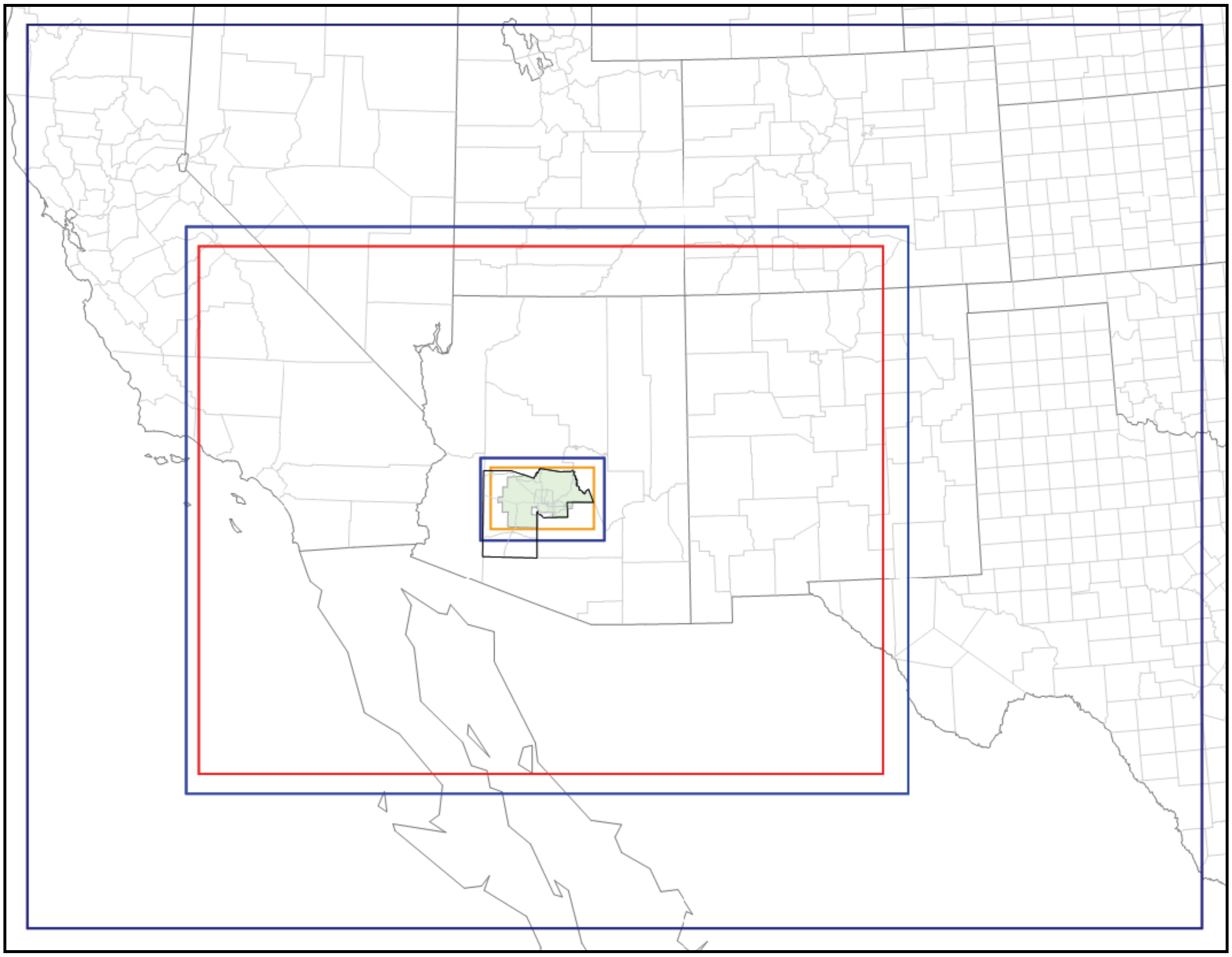

Figure 2-3 Nested CAMx and MM5 Modeling Domains

Two CAMx domains:
- 12 km grid domain (red)
- 4 km grid domain (orange)

Three MM5 domains (blue):
- 36 km grid domain
- 12 km grid domain
- 4 km grid domain

The map projection is UTM Zone 12.

2.3 Air Quality Monitoring Data and Meteorological Data

2.3.1 Air Quality Monitoring Data

The primary sources of air quality data for the Maricopa County Eight-Hour Ozone Nonattainment Area (MNA) are the monitoring networks maintained by the Maricopa County Air Quality Department (MCAQD) and the Arizona Department of Environmental Quality (ADEQ). Air quality data for the MNA is also obtained from the monitoring network managed by the Pinal County Air Quality Department (PCAQD). The PCAQD monitoring sites are not located in the MNA but are inside the CAMx inner modeling domain. Table 2-2 and Figure 2-4 present the locations of the ozone monitoring sites located in the CAMx inner modeling domain.

Air quality monitoring data from the MCAQD, ADEQ, and PCAQD monitoring networks were used in the review of ozone episodes (MAG, 2007a). However, data from monitoring sites with incomplete data and those sites lying outside the eight-hour ozone nonattainment area (MNA) were not used in the episode evaluation. The monitoring data have also been used to assess the ability of the model to replicate a historical eight-hour ozone episode, that is, to evaluate model performance for the base case (MAG, 2007a). This topic is addressed in the relevant section of the modeling protocol below.

2.3.2 Meteorological Data

The modeling demonstration of the eight-hour ozone maintenance plan will use the same MM5 meteorology data previously provided by ENVIRON for use in the Eight-Hour Ozone Plan (MAG, 2007a). The meteorological observations, the large-scale meteorological analysis fields, and other data sets required by MM5 are summarized below. The procedure for model performance evaluation and improvement of MM5 modeling is also briefly described in the following text.

Meteorological observations were obtained by MAG (MAG 2005) from three monitoring networks in the Maricopa County area and throughout Arizona: 1) Surface meteorological sites in the Arizona Meteorological Network (AZMET), 2) National Oceanic and Atmospheric Administration's National Weather Service (NOAA/NWS), and 3) Four upper air profiler sites operated by the NOAA's Forecast Systems Laboratory (FSL). Table 2-3 identifies the meteorological stations operated by these three networks, and Figure 2-5 illustrates the location of each meteorological station. It should be noted that the twentythree AZMET monitoring stations, operated by the University of Arizona, are not traditional weather stations; these stations' main purpose is to provide meteorological data for agricultural and horticultural interests in southern and central Arizona. The standard National Center for Atmospheric Research's NWS (NCAR/NWS) hourly surface observation dataset (referred to as "DS472") was also obtained to augment MAG's meteorological databases and to cover the entire region encompassed by the MM5 domain. The above meteorological data were used for direct input to MM5's Four Dimensional Data Assimilation (FDDA) system; and have also been used in the qualitative and statistical model performance evaluations.

Other datasets needed for MM5 modeling include terrain elevation, landuse/landcover, and large-scale meteorological analysis fields. The large-scale analyses are used for prescribing initial and boundary conditions and for analysis nudging MM5 during integration as part of its FDDA system. The analyses were extracted from the NCEP NAM/Eta Data Assimilation System (EDAS), which provides 40 km grid North American analyses every 3 hours. All of the needed datasets listed above were procured directly from the National Center for Atmopsheric Research (NCAR).

The MM5 simulations produced the required meteorological inputs (e.g., wind, temperature, humidity, and pressure) for MAG's air quality modeling. Both analysis nudging and observational nudging have been applied, and an extensive MM5 performance evaluation was conducted using the meteorological observations mentioned above for each 8-hour ozone episode. Sensitivity runs were conducted to find the optimal configuration for the best MM5 performance in terms of replicating surface wind, temperature, and humidity for the MNA; and also for the best CAMx model performance that uses the MM5 meteorology, in terms of consistency between simulated ozone and the monitored ozone values.

Three nested domains (4/12/36 km grids) were set up in MM5. The modeling domains for MM5 are larger than the inner and outer air quality modeling domains, as shown in Figure 2-3. Therefore, the meteorological fields for the air quality model applications are a subset of the MM5 wind fields. This approach diminishes the errors propagating from the modeling domain boundaries to the area of interest. Other input variables required by CAMx include cloud cover and UV radiation, which are not directly simulated by MM5, but are diagnosed or calculated in CAMx.

MAG will evaluate using the meteorological output from NCAR's Weather Research & Forecasting (WRF) model for use in the CAMx model (i.e., as a replacement for MM5 meteorological data). WRF is a next-generation mesoscale forecast model and data assimilation system that represents state-of-the-art weather prediction techniques. WRF will be set up with the same MM5 domain and vertical structures that were used in the Eight-Hour Ozone Plan. If the CAMx model's performance is noticeably improved with the WRF data, rather than with the MM5 data, MAG will use the WRF data in its CAMx modeling for this study.

2.4 Vertical Resolution

There are 35 vertical layers in the MM5 simulation, which is based on the WRAP CMAQ/CAMx regional modeling configuration. CAMx layers are allowed to span several MM5 layers, and thus are defined as a subset of the MM5 layers. The number of vertical layers in the CAMx 12 km grid modeling domain is 20; and there are 23 layers in the CAMx 4 km grid modeling domain. The top pressure is fixed at 100 millibars (mb), which corresponds to a vertical height of approximately 16 km. The vertical resolution is much finer in the lower layers than in the upper layers, with a total of 16 layers in the planetary boundary layer (PBL). The thickness of the lowest four layers is approximately 36 meters. This vertical structure exceeds the minimum standards recommended by EPA guidance (EPA 2007).

2.5 Specification of Initial and Boundary Conditions for CAMx

ENVIRON provided the initial and boundary conditions (IC/BC) data for the CAMx 12 km grid modeling domain. The data were extracted from the 36 km grid air quality simulations made with EPA's Models-3 CMAQ (version 4.5) using CMAQ's ICON/BCON processors. These input files were subsequently converted to CAMx IC/BC inputs using the CMAQ2CAMx-v2 interface utility developed by ENVIRON. The IC/BC data for the inner 4 km grid modeling domain were obtained from the CAMx output for the outer 12 km grid modeling domain.

Table 2-2 Ozone Monitoring Sites

Abbr.	Name	AIRS Code	Operator	Location	Data Availability	O_3	CO	NO	NO_2	WS/WD
AJ*	Apache Junction	04-021-3001	PCAQD	305 E Superstition Blvd	2002-2004	√				
BP†*	Blue Point	04-013-9702	MCAQD	Usery Pass & Bush	2000-2004	√				√
BE	Buckeye	04-013-4011	MCAQD	26453 W MC85	Since 8/1/2004	√	√		√	√
CC*	Cave Creek	04-013-4008	MCAQD	37019 N Lavon Ln	Since 8/1/2001	√				√
CP†*	Central Phoenix	04-013-3002	MCAQD	1845 E Roosevelt	2000-2004	√	√		√	√
DY	Dysart	04-013-4010	MCAQD	16825 N Dysart	Since 7/21/2003	√	√			√
EM	Emergency Management	04-013-3004	MCAQD	52nd St & McDowell Rd	Till 5/31/2001	√				
FF†*	Falcon Field	04-013-1010	MCAQD	4530 E Mckellips	2000-2004	√				√
FH†*	Fountain Hills	04-013-9704	MCAQD	16426 E Palisades	2000-2004	√				√
GL†*	Glendale	04-013-2001	MCAQD	6000 W Olive	2000-2004	√	√			√
HM†*	Humboldt Mountain	04-013-9508	ADEQ	7 Springs Rd	2000-2004	√				
LP*	Lake Pleasant	04-013-9805	MCAQD	41402 N 87th Ave	Till 7/31/2001	√				√
MRCP**	Maricopa	04-021-3010	PCAQD	44625 W Garvey Rd	Since 7/1/2002	√				
MV*	Maryvale	04-013-3006	MCAQD	6180 W Encanto	2000-2003	√	√			
ME*	Mesa	04-013-1003	MCAQD	370 S Brooks	2000-2002	√	√			√
MORD*	Mount Ord	04-013-9701	ADEQ	Mountain Ord Summit	5/19/2000-2001	√				√
NP†*	North Phoenix	04-013-1004	MCAQD	610 E Butler	2000-2004	√	√			√
PALV†*	Palo Verde	04-013-9993	ADEQ	36248 W Elliot Rd	2000-2004	√		√	√	
PP†*	Pinnacle Peak	04-013-2005	MCAQD	25000 Windy Walk Way	2000-2004	√	√			√
QC**	Queen Creek	04-021-3009	PCAQD	301 E Combs Rd	Since 7/1/2002	√				
QV**	Queen Valley	04-021-8001	ADEQ	10 S Queen Ann	Since 5/23/2001	√		√	√	
RV†*	Rio Verde	04-013-9706	MCAQD	N Forest Rd & Del Ray Ave	2000-2004	√				
SAC**	Sacaton	04-021-7001	Tribal	35 Pima St	Since 7/1/2002	√				
SP†*	South Phoenix	04-013-4003	MCAQD	33 W Tamarisk Ave	2000-2004	√	√			√
SS†*	South Scottsdale	04-013-3003	MCAQD	2857 N Miller Road	2000-2004	√	√		√	√
SUPR†*	Super Site	04-013-9997	ADEQ	4530 N 17th Ave	2000-2004	√	√	√	√	√
SU	Surprise	04-013-4007	MCAQD	18600 N Reems Rd	2001-7/14/2003	√	√			
TEMP*	Tempe	04-013-4005	MCAQD	1525 S College Ave	Since 7/1/2000	√	√		√	√
TNM**	Tonto National	04-007-0010	ADEQ	South of SR88	Since 5/24/2002	√		√	√	
WC	West Chandler (old)	04-013-3009	MCAQD	163 S Price Rd	Till 5/31/2000	√	√			√
WC*	West Chandler	04-013-4004	MCAQD	Ellis St & Frye Rd	Since 8/1/2000	√	√			√
WP†*	West Phoenix	04-013-0019	MCAQD	3847 W Earll Rd	2000-2004	√	√		√	√

† Monitoring sites having a complete data record.

* Monitoring sites having 8-hour ozone exceedance at least once during the period (2000-2004) that affected selection of episodes to be modeled.

** Monitoring sites inside of the inner model domain but outside of the 8-hour ozone nonattainment area. Data from these sites were used for model performance evaluation.

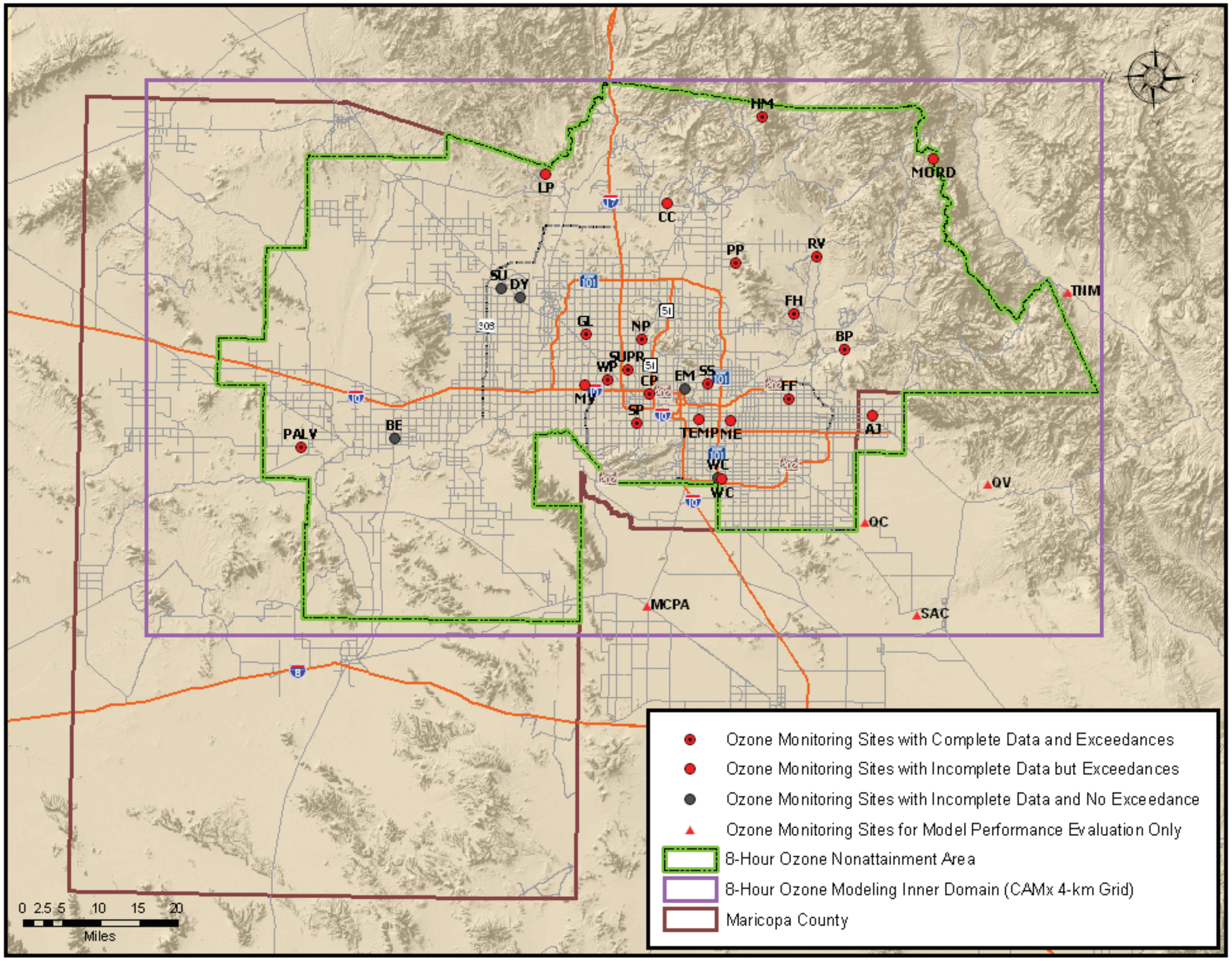

Figure 2-4 Ozone Monitoring Sites

Table 2-3 Meteorological Monitoring Stations

NWS (33 sites)								
Site	Abbr.	Lat	Lon	UTM (Zone 12)		Elev.	Address	County
				Northing (m)	Easting (m)	(m)		
Casa Grande Municipal Airport	KCGZ	32.95000	-113.76389	3646004.74	428339.63	446	510 E. FLORENCE BLVD, Casa Grande	Pinal
Chandler Municipal Airport	KCHD	33.26917	-113.93306	3681421.13	424459.38	379	2380 S. STINSON WAY, Chandler	Maricopa
Davis-Monthan Air Force Base	KDMA	32.16667	-111.44806	3558916.01	511000.13	824	DAVIS-MONTHAN AFB, Tucson	Pima
Douglas Bisbee International Airport	KDUG	31.46917	-112.42222	3482443.65	632656.74	1266	1415 MELODY LANE, BLDG C, Douglas	Cochise
Phoenix Deer Valley Municipal Airport	KDVT	33.69028	-110.72083	3728325.15	401239.94	450	702 W DEER VALLEY DR, Phoenix	Maricopa
Tucson NEXRAD	KEMX	31.88300	-110.00556	3527531.19	536222.38	1586	Tucson	Pima
Mesa/Falcon Field	KFFZ	33.46667	-109.37917	3703264.45	431857.54	424	4800 FALCON DR, Mesa	Maricopa
Flagstaff	KFGZ	36.21700	-111.67222	4008326.71	426567.23	2192	Flagstaff	Coconino
Libby AAF Fort Huachuca	KFHU	31.60000	-111.81700	3496292.91	563243.03	1438	401 GIULIO CESARE AVE, Sierra Vista	Cochise
Flagstaff Pulliam Airport	KFLG	35.14028	-112.15472	3888806.53	438763.21	2137	6200 S. PULLIAM DR, 204, Flagstaff	Coconino
Flagstaff NEXRAD	KFSX	34.56700	-114.55944	3825044.89	481654.04	2260	Flagstaff	Coconino
Gila Bend U.S. Army Airfield	KGBN	32.43333	-112.68333	3589715.73	341743.08	262	Gila Bend	Maricopa
Grand Canyon National Park Airport	KGCN	35.94611	-110.61700	3978587.39	395854.86	2014	Grand Canyon	Coconino
Glendale Municipal Airport	KGEU	33.52722	-112.38333	3710488.09	379721.07	325	6801 N. GLEN HARBOR BLVD 201, Glendale	Maricopa
Goodyear Municipal	KGYR	33.41667	-110.84583	3698335.76	371380.94	295	1658 SO LITCHFIELD RD, Goodyear	Maricopa
Laughlin/Bullhead International	KIFP	35.15750	-110.33333	3893236.68	722300.40	212	2550 LAUGHLIN VIEW DR, Bullhead City	Mohave
Kingman Airport	KIGM	35.25778	-109.60361	3905575.22	233156.32	1050	7000 FLIGHTLINE DR, Kingman	Mohave
Winslow Municipal Airport	KINW	35.02806	-110.95528	3876190.43	525466.06	1505	21 WILLIAMSON AVE, Winslow	Navajo
Mesa Williams Gateway Airport	KIWA	33.31660	-109.63556	3686574.65	439496.98	421	6001 SOSSAMAN RD, Mesa	Maricopa
Williams AFB/Chandler	KIWA	33.31667	-111.76667	3686574.65	439496.98	421	6001 SOSSAMAN RD, Mesa	Maricopa
Luke Air Force Base/Phoenix	KLUF	33.53333	-111.81111	3711271.17	371553.24	332	LUKE AFB, Glendale	Maricopa
Yuma Marine Corps Air Station	KNYL	32.62361	-109.06667	3612935.22	240675.79	64	Yuma	Yuma
Nogales International Airport	KOLS	31.42083	-111.73333	3476252.27	514652.98	1198	Nogales	Santa Cruz
Page Municipal Airport	KPGA	36.92056	-112.06556	4086153.63	460091.83	1314	697 VISTA AVENUE, Page	Coconino
Phoenix Sky Harbor International	KPHX	33.43417	-111.65000	3699914.60	402291.25	345	3400 SKY HARBOR BLVD, Phoenix	Maricopa
Prescott Love Field	KPRC	34.64917	-111.65000	3835058.29	369663.82	1537	6546 CRYSTAL LANE, Prescott	Yavapai
Wind Rock Airport	KRQE	35.65000	-112.29528	3946850.91	675023.86	2055	Window Rock	Apache
Safford Municipal Airport	KSAD	32.85722	-111.91056	3636283.38	627670.20	968	4550 E AVIATION WAY, Safford	Graham
Scottsdale Airport	KSDL	33.62278	-114.60000	3720703.49	415540.50	460	15000 N AIRPORT DR, Scottsdale	Maricopa
St. Johns Industrial Airpark	KSJN	34.51833	-111.20000	3820822.44	648772.04	1747	St. Johns	Apache
Show Low Regional Airport	KSOW	34.26528	-110.88333	3792017.67	591549.62	1955	3150 AIRPORT LOOP, Show Low	Navajo
Tucson International Airport	KTUS	32.13139	-112.05111	3555000.31	504218.01	805	Tucson	Pima
Yuma International Airport	KYUM	32.65000	-112.38333	3615031.47	725106.73	65	2191 E 32ND ST, Yuma	Yuma

Table 2-3 Meteorological Monitoring Stations (Continued)

AZMET (23 sites)

Site	Abbr.	Lat	Lon	UTM (Zone 12) Northing (m)	UTM (Zone 12) Easting (m)	Elev. (m)	Address	County
Aguila	AGUI	33.946667	-113.188889	3758401	297716	655	0.6 Miles NW of Aguila City Limits	Maricopa
Bonita	BONI	32.463611	-109.929444	3592330	600610	1346	18 Miles N on Rex Allen Dr from Willcox at I-10	Graham
Buckeye	BCK1	33.400000	-112.683333	3696899	343454	304	3.5 km S of Exit 109 from I-10	Maricopa
Coolidge	COOL	32.980000	-111.604722	3649232	443496	422	0.8 km SW of the Curry Rd & Bechtel	Pinal
Eloy	ELOY	32.773889	-111.556944	3626358	447840	461	0.8 km E of 11 Miles Corner Rd on Arica Rd	Pinal
Harquahala	HARQ	33.483333	-113.116667	3706876	303337	350	1.8 km N of the Intersection of Courthouse Rd & 491st Ave	Maricopa
Laveen	LAVE	33.376389	-112.150000	3693605	393027	315	3921 W Baseline Rd	Maricopa
Litchfield	LITC	33.467222	-112.398056	3703959	370087	309	1 Mile N of McDowell Rd on Cotton Ln	Maricopa
Marana	MARA	32.461111	-111.233333	3591572	478071	601	1 Mile W of I-10 on Trico-Marana Rd	Pima
Maricopa	MARI	33.068611	-111.971667	3659313	409299	361	NW corner of field #5 S of Irrigation Lab Building	Pinal
Mohave	MOHA	34.967222	-114.605833	3872026	718581	146	14.2 Miles S of Bullhead City on AZ Route 95	Mohave
Paloma	PALO	32.926667	-112.895556	3644751	322765	219	9 Miles W of Gila Bend on I-8 to Paloma Exit	Maricopa
Parker	PARK	33.882778	-114.447778	3752091	736045	94	8 Miles S of Poston & 0.4 Miles E on Nez Rd	La Paz
Phx. Encanto	ENCA	33.479167	-112.096389	3704947	398135	335	SE of Thomas Rd & 19th Ave (Encanto Golf Course)	Maricopa
Phx. Greenway	PGRN	33.621389	-112.108333	3720728	397193	401	SE of Greenway & 23rd Ave (Cave Creek Golf Course)	Maricopa
Queen Creek	QUEE	33.258333	-111.641667	3680110	440233	430	0.1 km E of Queen Creek Rd & Ellsworth Rd	Maricopa
Roll	ROLL	32.744444	-113.961111	3626837	222539	91	County 4th St & Ave 39 E	Yuma
Safford	SAFF	32.813333	-109.678333	3631367	623729	901	0.8 km SE of Lone Star Rd & Mountain Rd	Graham
Tucson	TUCS	32.280278	-110.945833	3571504	505101	713	1 km NW of Campbell Ave & Roger Rd	Pima
Waddell	WADD	33.618056	-112.459722	3720763	364592	407	2 Miles W of Cotton Ln & 0.4 Miles S of Greenway Rd	Maricopa
Yuma Mesa	YMES	32.611944	-114.633889	3610740	722021	58	0.32 km W of Ave A on 15th St	Yuma
Yuma North Gila	YUMA	32.735278	-114.529444	3624641	731506	44	2.1 km W on 7th Ave from Gila Center	Yuma
Yuma Valley	YVAL	32.712500	-114.705000	3621744	715106	32	5 Miles W of Yuma on 8th St	Yuma

FSL (4 sites)

Site	Abbr.	Lat	Lon	UTM (Zone 12) Northing (m)	UTM (Zone 12) Easting (m)	Elev. (m)	Address	County
Flagstaff/Bellemt	FGZ	35.23	-111.82	3898858	425383	2179	123 miles North from Central Phoenix	Coconino
Tucson	TUS	32.12	-110.93	3553739	506603	788	113 miles South from Central Phoenix	Pima
Yuma/US Army	YUM	32.87	-114.33	3640036	749823	131	138 miles West from Central Phoenix	Yuma
Yuma/US Army	1Y7	32.87	-114.40	3639872	743271	98	142 miles West from Central Phoenix	Yuma

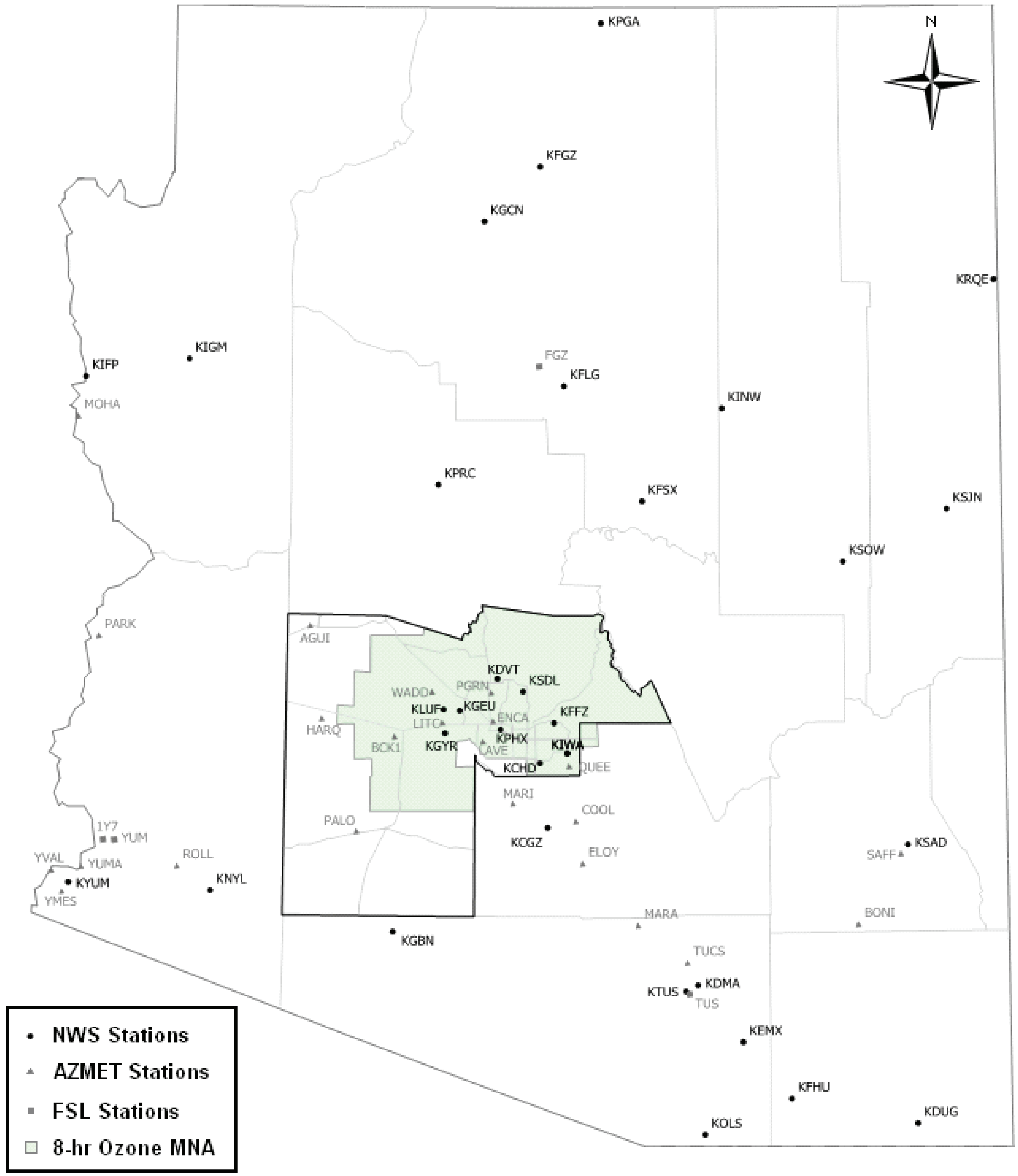

Figure 2-5 Meteorological monitoring stations

2.6 Episode Selection

Since the Eight-Hour Ozone Maintenance Modeling Demonstration employs the same base years used for the Eight-hour Ozone Plan, three elevated ozone episodes that occurred during the ozone seasons of the five years, 2000 through 2004, will be used for this modeling study. The historical patterns of ozone episodes and the fundamental meteorological regimes conducive to ozone formation in the area were taken into account in evaluating and justifying the selection of episodes. The selected episodes represent three different meteorological regimes that correspond to eight-hour ozone concentrations of at least 80 parts per billion (ppb). Wind flow patterns (e.g., well defined transport winds vs. light and variable winds) were the primary consideration for distinguishing among regimes. Region-wide temperature observations (e.g., high temperatures vs. less extreme temperatures) were also considered as a factor in selecting the modeling episodes. High ozone days were partitioned into the three major regimes recommended in EPA guidance (EPA, 2007). The detailed evaluation resulting in episode selection is provided in the MAG Eight-Hour Ozone Plan for the Maricopa Nonattainment Area (MAG, 2007a).

The primary criteria influencing the selection of the episode periods were:

- The episodes represent a variety of meteorological conditions that frequently correspond with eight-hour ozone exceedances at multiple monitoring sites;
- The episode days have eight-hour ozone concentrations that are close to the design value for each monitor;
- There are adequate emissions, air quality, and meteorological data available for the maintenance test for these periods; and
- The selected episodes have a sufficient number of days to base the modeled maintenance test on (e.g., more than one day at each violating monitor).

Three high eight-hour ozone episode periods were selected based on the detailed analysis described in the Eight-Hour Ozone Plan. The three episodes are:

1. July 8-14, 2002 (Regime 1)
2. June 3-7, 2002 (Regime 2)
3. August 5-11, 2001 (Regimes 2 and 3).

The first episode (Regime 1) is characterized by stagnation and locally-generated ozone. It contains the highest 8-hour ozone concentration measured in the MNA between 2001 and 2004 and includes weekend exceedances. During this period, there were 17 sites with peak ozone concentrations greater than 85 ppb and 8 sites measured their fourth-highest concentrations of the year. This episode ranked the highest of the six candidate episodes that were evaluated.

The second episode (Regime 2) is characterized by higher surface winds, with potential transport mainly from the south and southwest. This episode does not include weekend exceedances. During this period, there were 8 sites with ozone concentrations above 85 ppb and 9 sites measured their fourth-highest concentrations of the year. This episode ranked third highest among the six candidates evaluated.

The third episode (Regimes 2 and 3) is characterized by higher surface winds, with both locally generated and transported ozone. It includes weekend ozone exceedances and has 11 sites with concentrations above 85 ppb. This episode was fourth highest among the candidates evaluated.

These three episodes will be modeled in order to reflect the full range of meteorological, transport, and emissions-generation conditions that are characteristic of high ozone days in the MNA. Three spin-up days will be added to each episode, resulting in a total of 28 days to be modeled.

2.7 Emission Inventories

Emission inventories consist of emissions from point, area, onroad mobile, nonroad mobile and biogenic sources. For this modeling analysis, the nonroad mobile source category includes aviation and locomotive emissions, in addition to gasoline and diesel-powered equipment, ranging from lawn and garden equipment to construction equipment. The version 3.0 of Emissions Preprocessor System (EPS3.0) will be used to process emission inventories for the 8-hour ozone maintenance modeling demonstration. EPS3.0 is an updated and improved version of EPS2.0 provided to MAG by ENVIRON. EPS3.0 consists of a set of FORTRAN programs (modules) that are executed sequentially in order to prepare the gridded emission inventory for use in photochemical air quality modeling.

Point, area, and nonroad mobile source emissions will be temporally adjusted and spatially allocated in the grid cells by EPS3.0, while hourly gridded onroad and biogenic emissions will be directly developed by emission models such as MOBILE6.2 and M6Link for onroad emissions and the Model of Gases and Aerosols from Nature (MEGAN) for biogenic emissions. More details on these models are described in Sections 2.7.2 and 2.7.3 of this protocol. Prior to the CAMx model run, gridded emissions for each source will be merged by the mrguam module of EPS3.0 and be reformatted for use in the CAMx model.

Emission inventories for the maintenance year 2025 will be developed for the same three episodes developed in the MAG Eight-Hour Ozone Plan to demonstrate attainment for the MNA in 2008. For the 2025 emission inventories, the latest 2005 emission inventories for ozone precursors, which were submitted for the EPA National Emission Inventory (NEI) database, will be adjusted to reflect emissions expected to occur in 2025. Emissions will also be adjusted to reflect control programs and activity levels expected to occur in 2025. The general methodology for creating the 2025 emissions will be based on EPA guidance for the preparation of emissions projections (EPA, 1991). These adjustments will entail the use of growth factors, ongoing and new control programs, and retirement rates for obsolete sources of emissions. The growth factors used to create the 2025 emission inventories will reflect the latest socioeconomic projections adopted by the MAG Regional Council in May, 2007. The impact of the committed control measures will be reflected in the 2025 emission inventories. Table 2-4 summarizes the daily ozone precursor emissions for the five major source categories during the 2005 ozone season in Maricopa County.

Table 2-4 Average Daily Emissions in Maricopa County for 2005 Ozone Season (MCAQD, 2008)

	VOC		NOx		CO	
	lbs/day	**%**	**lbs/day**	**%**	**lbs/day**	**%**
Area	482,211	30.43	150,465	20.53	4,911,645	56.01
Nonroad Mobile	159,437	10.06	185,433	25.31	2,014,686	22.97
Onroad Mobile	189,915	11.99	352,527	48.11	1,725,438	19.68
Biogenic	726,222	45.83	18,196	2.48	107,165	1.22
Point	26,702	1.69	26,129	3.75	10,491	0.12
Total	1,584,487	100	732,750	100	8,769,425	100

2.7.1 Treatment of Point and Area Source Emissions

Except for power plant emissions, the 2025 emissions will be developed by projecting point and area source emissions from the 2005 periodic emission inventories of ozone precursor emissions developed by the Maricopa County Air Quality Department (MCAQD) and the Pinal County Air Quality Control District (PCAQCD). MAG will work with MCAQD and PCAQCD to develop the growth factors needed to project the point and area source emissions from the 2005 periodic emission inventories. Power plant emissions for the year 2025 will conservatively assume the potential to emit (PTE) emissions provided by MCAQD and PCAQCD. The locations of power plants in Maricopa County are provided in Table 2-5.

2.7.2 Treatment of Mobile Source Emissions

On January 29, 2002, EPA announced the official release of the MOBILE6 model for regulatory use outside of California. MOBILE6.2 is the latest update of the onroad mobile source model developed by EPA to estimate fleet-wide vehicle emission factors. The 2025 onroad mobile source emissions for the eight-hour ozone maintenance modeling demonstration will be developed using the MOBILE6.2 and MAG M6Link models. It should be noted that the onroad mobile source portion of the 2005 periodic emission inventories for ozone precursors was also developed using the MOBILE6.2 and M6Link models. The latest socioeconomic data and transportation system assumptions available in 2008 will be employed in developing onroad mobile source emissions for the year 2025.

MOBILE6.2 uses a variety of inputs. Each modeled scenario will require at least ten runs: a minimum of one Inspection and Maintenance (I/M) run and a non-I/M run for each of the five area types included in the transportation modeling area: central business district, urban, urban fringe, suburban, and rural. The results from these runs will be weighted appropriately to reflect the actual proportions of I/M and non I/M vehicles within the nonattainment area. In addition, the inputs for each run will include Reid Vapor Pressure (RVP), oxygen, gasoline and diesel sulfur contents, and values appropriate for the summer ozone season. The temperature range will reflect episode day conditions in the nonattainment area. Note that these values will vary depending upon the episode period being modeled. The 2025 maintenance modeling demonstration will reflect control measure assumptions for the pertinent commitments contained in the MAG Serious Area Plans for PM-10 (MAG, 2000) and CO (MAG , 2001), the One-Hour Ozone Maintenance Plan (MAG, 2004), the Eight-Hour Ozone Plan for the Maricopa Nonattainment Area (MAG, 2007a), and the Five Percent Plan for PM-10 (MAG, 2007b), where appropriate. The modeling will also include benefits for the controls passed by the Arizona Legislature in S.B. 1552.

Table 2-5 Power Plants in Maricopa County

Power Plant	Location	City	UTM (Zone 12, km)	
			Easting	Northing
APS W est Phoenix Power Plant	Hadley St.	Phoenix	392,414	3,701,190
Duke Energy Arlington Valley	Elliot Rd.	Arlington	323,858	3,691,307
New Harquahala Generating Co.	491st Ave.	Tonopah	303,688	3,705,787
Mesquite Generating Station	Elliot Rd.	Arlington	326,602	3,691,016
Ocotillo Power Plant	University Dr.	Tempe	415,224	3,698,573
Gila River Power Station	Watermelon Rd.	Gila Bend	341,737	3,696,527
Redhawk Generating Station (Pinnacle)	363rd Ave.	Arlington	328,940	3,690,200
Santan Generating Plant	Val Vista Dr.	Gilbert	430,407	3,688,183
SRP Agua Fria Generating Station	Northern Ave.	Glendale	387,108	3,713,387
SRP Kyrene Steam Plant	Kyrene Rd.	Tempe	412,877	3,691,004

MOBILE6.2 generates emission factors which incorporate local vehicle speeds, episodic temperatures and soak distribution. These emission factors will be utilized by the M6Link system to estimate onroad mobile source vehicle emissions for the inner modeling domain. The M6Link system is a FORTRAN-based set of programs (M6Link1 and M6Link2) that are applied at the regional level to examine transportation and related air quality issues. The system is designed to read in files created by the MAG transportation models, and extract the relevant data needed for an air quality analysis, including data needed to run the MOBILE6.2 model. The M6Link1 extracts data such as roadway link speeds, locations, and vehicle miles of travel (VMT) and assigns link VMT to the correct hour and grid cell accordingly. M6Link1 also factors link VMT to be consistent with Highway Performance Monitoring System VMT by functional system.

The MOBILE6.2 program is run using the output from M6Link1 as part of its input data. The output from MOBILE6.2 is then used as one of the inputs to M6Link2, the second program of the M6Link system. M6Link2 combines the output from M6Link1 and the output of MOBILE6.2 to produce hourly gridded emissions, suitable for input to the photochemical air quality model. These results incorporate locally-derived hourly VMT splits, vehicle speed distribution, VMT by vehicle class for area and roadway type, fuel characteristics, and temperatures, to ensure results appropriate to episode conditions. In addition to CAMx-ready files, M6Link2 produces tables summarizing VMT and vehicle hours traveled (VHT) by facility type and area type. Also, tables summarizing emissions totals by hour, facility type, or emissions source (i.e. exhaust vs. evaporative) are produced. EPS3.0 will be used to combine the M6Link output with the emissions of other source categories (e.g., point, area, and biogenic emissions) to create the emissions file used by the photochemical air quality model.

2.7.3 Treatment of Nonroad Mobile Emissions

MAG will use EPA's NONROAD2005 model to estimate ozone precursor emissions for all nonroad mobile sources, except aircraft and ground support equipment. The MAG Airport Emissions Model will be employed to estimate emissions from aircraft and ground support equipment. The forecasted 2025 nonroad emissions will be developed by applying 2025 emission factors and 2025 growth factors to 2005 nonroad vehicle activity and population data.

Locomotive emissions will be estimated by applying EPA 2025 emission factors to 2005 activity data provided by the Union Pacific and the Burlington Northern Santa Fe Railroads. No growth in locomotive activities will be assumed in the modeling, which is consistent with the assumption in the MAG Five Percent Plan for PM-10 (MAG, 2007b). In estimating emissions from aircraft and ground support equipment, MAG Airport Emissions Model (AEM) will be employed. Detailed descriptions of the model are available in the report by Systems Applications International (MAG, 1996). Emission factors for estimating aircraft emissions will be calculated using the FAA Aircraft Engine Emissions Database (FAEED) and supplemented with emission factors not included in the FAEED database, based on EPA guidance (EPA, 2007). Aircraft operation for the 2025 future year will be obtained from MAG Regional Aviation System Plan (RASP) Update 2006 (MAG, 2006). The same growth factor will be applied in estimating the 2025 ground service equipment activity levels at each airport in Maricopa County.

2.7.4 Treatment of Biogenic Emissions

Biogenic emissions developed for the three high ozone episodes in the MAG Eight-Hour Ozone Plan (MAG, 2007a) will be assumed to remain constant for the year 2025. Biogenic emission estimates for the modeling domain were derived using the MEGAN model. MEGAN is an acronym for Model of Emissions and Gases and Aerosols from Nature, which was developed by ENVIRON. The emission factors in MEGAN were updated and added for local vegetation based on the results of a field study to identify prevalent plant species in Maricopa County, including their locations and biomass density (Guenther, A., 2006a and 2006b). MEGAN reads in gridded meteorological data (i.e., temperature, solar radiation, humidity, soil moisture, etc.) generated by MM5 and vegetation characteristics such as monthly leaf area index (LAI), plant function type (PFT), and emission factors as inputs. MEGAN creates an EPS3.0 ready hourly gridded emission file as output.

2.7.5 Temporal Allocation of Emissions

To predict hourly concentrations of ozone, CAMx requires hourly estimates of emissions for each grid cell in the modeling domain. Hourly biogenic and onroad mobile source emissions will be directly generated by biogenic and onroad models so that these emissions do not need to go through temporal adjustment process of EPS3.0. However, since point, area, and nonroad emissions are provided as daily emissions for the ozone season, point source emissions will be resolved to hourly emissions using available operating schedule data, while area and nonroad emissions will be temporally adjusted based on profiles for seasonal, day of week, and diurnal patterns of activities.

2.7.6 Spatial Allocation of Emissions

The point source emission inventory includes UTM coordinates for each source. The emissions are allocated to the appropriate grid cells according to the UTM coordinates of the source. However, since area and nonroad emissions are provided as county-level emissions, spatial surrogates need to be used to allocate these emissions to the appropriate grid cells. The assumption using spatial surrogates is that emissions from each source behave spatially in the same manner as the spatial surrogate indicator. Fourteen spatial surrogates will be developed based on socio-economic data, MAG General Plan, and MAG GIS data. The fourteen spatial surrogate codes and categories are provided in Table 2-6. The MAG transportation model will assign travel demand data to 2025 highway networks which will be used to spatially distribute onroad mobile source emissions.

2.8 Quality Assurance

The purpose of quality assurance testing is to establish that good model performance is the result of valid model inputs and assumptions, and not the result of compensating errors in input data. Prior to conducting modeling analysis, individual air quality, meteorological, and emissions data components will be reviewed for consistency and obvious omission errors. Both spatial and temporal characteristics of the data will be evaluated. Examples of component testing include:

- **Air Quality** - Air quality data will be checked for correct order of magnitude and values will be compared with monitored data to assure reasonable speciation.

- **Meteorology** - Surface and elevated wind vectors will be plotted and compared with monitoring stations and weather maps for consistent patterns. Temperature fields will be checked.

- **Emissions** - The emission inventories will be tabulated, plotted, and examined. The quality assurance procedures will include documentation of major assumptions, careful accounting of emissions totals throughout the development process, verification of spatial distribution of emissions against known source locations and emission strengths, and identification of missing or unreasonable data values.

It is crucial to perform the quality assurance tests prior to performing model simulations. Errors uncovered by the quality assurance testing of component input fields might be extremely difficult to diagnose later in the modeling process where errors could arise from any subset of the data inputs.

Table 2-6 Spatial Surrogate Codes and Categories

Code	Categories	Data Source
1	Housing	2025 Projected Socio-economic Data
2	Industrial	MAG General Plan
3	Non-industrial	MAG General Plan
4	Undeveloped Total	MAG General Plan
5	Developed Total	MAG General Plan
6	Construction	MAG GIS Data
7	Agriculture - Stockyards	MAG GIS Data
8	Agriculture - Other Crops	MAG General Plan
9	Non-developable Forest	MAG GIS Data
10	Railroad	MAG GIS Data
11	Landfill	MAG GIS Data
12	Water	MAG General Plan
13	Golf Course	MAG GIS Data
14	Airport	MAG General Plan

3. MODEL PERFORMANCE EVALUATION

EPA recommends that model performance be evaluated in two ways - operational and diagnostic evaluations - prior to using photochemical modeling to support a maintenance demonstration (EPA, 2007). In addition to a discussion on performance evaluation, this section summarizes the performance evaluation results performed for the MAG Eight-Hour Ozone Plan (MAG, 2007a).

3.1 Operational Evaluation

An operational evaluation is a major method to assess how accurately the model predicts observed concentrations for specific cases. The results of an operational evaluation could be used as a benchmark for model performance and a reference for further model improvement. It is expected to conduct an operational evaluation of ozone model performance using the EPA-recommended statistical measures, graphical displays, and other analytical techniques. MAG will conduct the operational evaluation presented below:

Statistics - For hourly ozone and eight-hourly maxima ozone over the episode days in a maintenance demonstration, EPA recommends, at a minimum, to calculate three statistical measures including Mean Normalized Bias (MNB), Mean Normalized Gross Error (MNGE), and Average Peak Prediction Bias and Error. Along with the three metrics above, additional statistics such as mean bias, mean error, mean fractional bias, mean fractional error, root mean square error, correlation coefficients, etc. should be calculated. It is recommended to calculate these statistical measures for pairs in which the one-hour or eight-hour observed concentrations are greater than 60 ppb and for all pairs without threshold.

Plots/Graphics - EPA recommends to provide five sets of graphical displays, which are time series plots, scatter plots, quantile-quantile (Q-Q) plots, tile plots of daily maximum predicted ozone, and animations of predicted hourly ozone concentrations. It is recommended to provide these graphical displays for both one-hour and eight-hour ozone.

In the Eight-Hour Ozone Plan, MAG conducted operational evaluations for both statistical and graphical assessments of model versus observed pairs. The statistical analysis showed that the performance of CAMx for the June 2002 episode is satisfactory and acceptable by EPA standards; the graphical analysis indicated that the temporal and spatial characteristics of the observed ozone distribution patterns were reasonably replicated. It is concluded that CAMx can adequately replicate the ozone episode of June 2002, and therefore is suitable to use to predict future ozone concentration levels for the MNA. Although CAMx consistently underestimated monitored ozone concentrations for the July 2002 and August 2001 episodes, these two episodes provided a better understanding of the CAMx simulation under different meteorological situations.

3.2 Diagnostic Evaluation

A diagnostic evaluation is a potentially useful approach to understand whether the model predictions are plausible or not. The results of diagnostic evaluations could be used to explain model performance and to provide ideas about how to improve the reliability of model predictions. EPA provides a list of tools for diagnostic analyses and encourages air quality modelers to complete as many as possible. If WRF is selected as a meteorological model for CAMx, MAG will conduct as many diagnostic evaluations as possible. These evaluations are discussed below.

Photochemical Source Apportionment - As one of the embedded probing tools within CAMx, photochemical source apportionment tool provides information on the contribution of tagged primary emission sources, source categories, source regions, initial conditions and/or boundary conditions to simulated concentrations and deposition in a single model run. This tool could be used to estimate how emissions from individual source areas and regions influence predicted ozone concentrations over space and time.

Decoupled Direct Method (DDM) - In a single model run, the DDM provides information for model sensitivity to various emissions reductions of model inputs (e.g., initial conditions, boundary conditions, and emissions).

Chemical Process Analysis (CPA) - As one of the most common process analysis tools implemented in grid models, the CPA provides details on the chemical transformations in CAMx simulation.

Sensitivity Tests - Sensitivity tests are useful methods to determine the response of the photochemical model to emissions reductions by using alternative model inputs or model algorithms. The parameters for sensitivity tests could include different chemical mechanisms in CAMx, different meteorological models (MM5 and WRF), different meteorological configurations, and different initial/boundary conditions.

Previously, MAG conducted three sensitivity tests as a diagnostic evaluation for the eight-hour ozone attainment plan to examine the model's sensitivity to changes in model inputs and to ensure that the model responses were physically and chemically realistic. First, a sensitivity to the initial conditions was tested and the results suggested that three ramp-up days were enough to eliminate major uncertainties introduced in the initial conditions. Second, a sensitivity to the boundary conditions was tested and the results indicated that the simulated ozone is fairly sensitive to the boundary conditions. It demonstrated that transported ozone and ozone precursors were responsible for about half of the predicted high ozone levels in the MNA during the June 2002 episode; while the high ozone concentrations were less sensitive to the boundary conditions in the other two episodes. Last, a sensitivity to emissions was tested by zeroing out area, biogenic, nonroad, onroad, and point source emissions, individually, as well as removing anthropogenic NOx and VOC emissions, separately. The results showed that the simulated ozone is most sensitive to onroad mobile emissions and least sensitive to point source emissions. Also it revealed that ozone concentrations increased with NOx reductions in the urbanized portion of the nonattainment area. This result was supported by Chemical Process Analysis (CPA), which provides the detailed physical and chemical processes within the model.

4. MAINTENANCE DEMONSTRATION

4.1 Identification of Maintenance Year

The year 2025 will be modeled as the maintenance year for this modeling demonstration to assure that the eight-hour ozone standard is maintained at least ten years after an official notice of redesignation to attainment by EPA.

4.2 Identification of Control Measures

The Arizona Legislature passed Senate Bill 1552 on June 20, 2007. The two ozone control measures adopted in the Bill will be considered in the maintenance modeling demonstration: Open Burning Ban during Ozone Season, and Liquid Leaker Test as part of Vehicle Emission Inspection. The future year emissions inventories will include emission reduction credits from the two new control measures and committed measures from the Eight-Hour Ozone Attainment Plan and Five Percent Plan for PM-10 (MAG, 2007b), where appropriate. If the modeling outlined in this protocol does not demonstrate maintenance of the standard with the committed control measures, including the two new control measures, the TSD will be revised to document any additional measures that will be necessary to attain the standard.

4.3 Maintenance Test

To demonstrate maintenance of the eight-hour ozone standard in 2025, the future design values near each monitor should not exceed 84 ppb. The future design values in 2025 will be predicted by multiplying a relative response factor (RRF) by a site-specific baseline design value (EPA, 2007). The site-specific RRF is the ratio of the mean of the eight-hour ozone daily maximum predictions in the future to the mean of the eight-hour ozone daily maximum predictions with baseline emissions near a site, over all primary episode days.

As EPA recommended in its guidance (EPA, 2007), MAG will utilize 49 grid cells (an array of 7 x 7 grid cells with the monitor located in the center grid) near each monitoring site to demonstrate maintenance in the CAMx 4 km grid modeling domain. Any deviation from the 7 x 7 grid array will be justified in the TSD.

The eight-hour ozone daily maximum predicted by CAMx in the 49 grid cells near a monitoring site will be computed for each day in the episode period (except spin-up days). These site-specific daily maximum values will be averaged over the episode days for each episode to obtain the future and baseline concentrations used in calculating the RRFs. Predicted baseline maxima below 70 ppb will be excluded from the analysis.

The baseline design values for the maintenance test will be obtained from the Eight-Hour Ozone Plan. These current design values are defined as the three year average of the fourth highest daily maximum eight-hour ozone concentration monitored at each site. The 2002 design value for each monitoring site is the average of the current design values for the periods: 2000-2002, 2001-2003, and 2002-2004. Similarly, the 2001 design value for each monitoring site is the average of the current design values for the periods: 1999-2001, 2000-2002, and 2001-2003. The 2002 design values with the RRF will be used to derive the future design values for the June and July episodes, while the 2001 design values with the RRF will be the future design values for the August episode. The maintenance test will be performed for the selected three episode periods that represent worst case conditions.

4.4 Modeling Reliability and Uncertainties

CAMx is considered to be an appropriate tool for projecting the future air quality impacts of changes in emissions (EPA, 2007). However, future year modeling results should not be considered an absolute guarantee of future air quality. Uncertainties in the models used and their inputs, along with meteorological variability, may result in actual future air quality that differs from predicted air quality. Any of the following reasons could result in higher ozone concentrations than those predicted with CAMx:

Meteorological Variability - In selecting a modeling episode, the goal is to select periods that represent worst-case conditions. If episodes with more severe stagnation occur in the future, emission controls designed to reach maintenance for a historical episode may not be adequate.

Emissions Variability – Emissions estimates are based on average source activity, taking into account temporal factors such as seasonal, diurnal, and day-of-week factors. Nonroad and onroad mobile emissions estimates take into account day-specific meteorological parameters as well. However, emissions on a given day may be greater than average due to above normal source activity and other factors.

Uncertainty in Growth Projections - If emission growth projections, based on population, underestimate true emission growth rates, future year emissions may be greater than projected emissions.

Uncertainty in Control Measure Effectiveness - If actual emission reductions from control measures are smaller than the estimated emission reductions, future concentration may be greater than predicted concentrations.

Model Performance - If the model underpredicts at a particular site or fails to capture a particular aspect of the meteorology, a level of emission reduction that appeared to be adequate in the modeling may not be adequate in the real world situation.

By similar reasoning, future monitored concentrations may be lower than predicted concentrations because of the previously mentioned variability and uncertainties. In addition, future monitored concentrations will still be limited to monitoring site locations. As a result, although modeled future design values below 85 ppb are adequate to demonstrate maintenance, modeling results are better thought of as points on a probability distribution. If the modeled peak values are below 80 ppb, the probability of eight-hour ozone maintenance in the future year is high even under differing conditions. If the modeled peak is very close to 85 ppb, however, the probability of eight-hour ozone maintenance in the future year may be well below 100 percent given the probabilistic nature of meteorology and modeling.

The relative response factor approach introduced by EPA (EPA, 2007) uses average values (modeled and monitored) that are more likely to result in an accurate assessment of maintenance under a variety of conditions. However, if the modeled maintenance test shows that some estimated future design values are close to the standard, MAG will conduct additional analysis, as described below.

5. SUPPLEMENTAL ANALYSES

When estimated future design values are very close to the standard, EPA recommends that corroboratory tests be performed (EPA, 2007). MAG will conduct additional analyses to confirm that maintenance of the eight-hour ozone NAAQS is likely to occur. If estimated future design values in 2025 exceed 82 ppb at one or more sites, a weight of evidence demonstration will be conducted to determine whether aggregate supplemental analyses support the modeled maintenance test. These supplemental analyses are discussed below.

5.1 Corroboratory Tests

In addition to the monitor based maintenance test, EPA recommends that a supplemental unmonitored area analysis should be applied in the nonattainment area (EPA, 2007). Along with the unmonitored area analysis, MAG will conduct other corroboratory tests.

5.1.1 Unmonitored Area Analysis

A review of unmonitored area analysis is intended to identify areas where predicted future year design values might be greater than the eight-hour ozone standard. In order to conduct this analysis, EPA recommends using gradient adjusted spatial fields to get more accurate estimates for the unmonitored areas. Gradient adjusted spatial fields, which are created by the combination of interpolated spatial fields of ambient data and gridded modeled outputs, take advantage of the strengths of these two datasets.

In order to implement gradient adjusted spatial fields, base year design values, which are also used in the monitor based model maintenance test, will be interpolated to develop ambient spatial fields. Secondly, the spatial fields will be adjusted using gridded base year model output gradients. Finally, model derived gridded RRFs will be applied to the gradient adjusted spatial fields to create future year fields. The future year gradient adjusted spatial fields will be evaluated to determine if any predicted values in grid cells remain above the 8-hour ozone standard.

MAG will use the Modeled Attainment Test Software (MATS) developed by EPA to conduct this analysis. If predicted violations of the unmonitored area analysis occur, MAG will determine whether the predicted violations were caused by an error or uncertainty in the modeling system.

5.1.2 Absolute Model Forecasts

The absolute modeling results for the 2025 forecast may be useful in corroborating the results using RRFs. Comparing future year and base case modeled ozone concentrations, metrics concerning the frequency, magnitude, and relative amount of nonattainment might include:

- Percent change in total amount of ozone greater than or equal to 85 ppb in the MNA
- Percent change in number of grid cells greater than or equal to 85 ppb in the MNA
- Percent change in grid cell hours greater than or equal to 85 ppb in the MNA
- Percent change in maximum modeled eight-hour ozone concentration in the MNA

5.1.3 Indicator Species

To assess which precursor for ozone (e.g., VOC or NOx) will limit production of ozone in the MNA in 2025, MAG will use the indicator species approach - CAMx Chemical Process Analysis (CPA) application - over the entire 4 km grid modeling domain (ENVIRON Memorandum, 2007). Since CPA provides detailed reaction rate information over groups of reactions in the chemical mechanism for a selected area, it is possible to quantify chemically meaningful attributes such as ozone and oxidant production/loss rates, radical initiation rates, radical propagation efficiencies, radical termination rates, HOx chain lengths, formaldehyde production rates, and NOy reaction rates. This analysis will be used to reveal important chemical information within the Phoenix urban plume for the maintenance modeling year 2025. The chemical information will be used to determine the VOC or NOx-limited status and severity of biogenic VOC contribution to the Phoenix urban plume. MAG will conduct an analysis for the Maintenance Plan to determine whether there is a NOx disbenefit in any part of the nonattainment area in the year 2025.

5.1.4 Other Corroboratory Tests

MAG will perform other tests to confirm and explain the results of the CAMx modeling. The CMAQ model may be applied to corroborate the CAMx results. Other corroboratory tests may include applying the photochemical source apportionment tool in CAMx to determine which sources are contributing to maintenance during the worst-case episode period in 2025.

5.2 Weight of Evidence Approach

MAG will submit weight of evidence approach along with corroborative tests to EPA. Past analyses have shown that future design value uncertainties of 2 - 4 ppb can result from the use of alternate, but equally appropriate, emissions inventories, chemical mechanisms, and meteorological inputs (EPA, 2007). The weight of evidence document will include trends of emissions and monitored ozone design values and results of CPA analysis, as well as the evidence, viewed as a whole, supporting a conclusion that the area will maintain the eight-hour ozone standard.

6. PROCEDURAL REQUIREMENTS

The following items will be delivered in draft form to the EPA regional office for review and comment during the modeling study. MAG will also provide draft versions of these items to the Air Quality Planning Team for review and comments.

- The modeling protocol.

- The Technical Support Document which addresses the entire modeling analysis, including MM5 or WRF and CAMx input preparation and application, and the maintenance demonstration.

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